A C T A I C H T H Y O L O G I C A E T P I S C A T O R I A

Abbrev.: Acta Ichthyol. Piscat. 31 (1): 141-150, Ann. 2001

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ZOOSPORIC FUNGI GROWING ON THE EGGS OF *COREGONUS LAVARETUS MARAENA* (BLOCH, 1779) FROM LAKE MIEDWIE IN POMERANIA

GRZYBY ZOOSPOROWE ROZWIJAJĄCE SIĘ NA IKRZE *COREGONUS LAVARETUS MARAENA* (BLOCH, 1779) Z JEZIORA MIEDWIE NA POMORZU

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The authors investigated of the mycoflora developing on the eggs of Miedwie whitefish (*Coregonus lavaretus maraena*). 32 aquatic zoosporic fungus species developed on the eggs, including 24 of the order Saprolegniales and 8 of the Peronosporales.

INTRODUCTION

Among the species of the genus *Coregonus* the whitefish is characterised by high morphological and physiological variability in the area where it occurs (Svärdson 1979). Thus, specific conditions of deep oligotrophic-like lake types exert an effect on certain morphological features of this species. For many centuries a number of forms have appeared; in the same lake the populations of *Coregonus lavaretus* may differ in morphological and physiological features and in the content of certain chemical elements (Czeczuga et al. 1991).

Based on the number of gill rakers on the first branchial arc, four whitefish subspecies have been distinguished in Poland (Heese 1992; Szczerbowski 1993) namely, the migrating whitefish (*C. lavaretus lavaretus* (L., 1758)) in the Pomeranian Bay, the holstein whitefish (*C. lavaretus holsatus* Thienemann, 1916) in Wdzydze Lake (Szczerbowski 1969), the noble whitefish (*C. lavaretus generosus* (Peters, 1874)) in the lakes of Warmia, Masuria, and Suwałki District, and the Miedwie whitefish (*C. lavaretus maraena* (Bloch, 1779)) from Lake Miedwie in Western Pomerania. Moreover, Heese (1992) describes peipus whitefish (*C. lavaretus maraenoides* (Poljakow, 1874)) from Gołdapiwo Lake in

Masuria, which according to some investigators is a subspecies of the noble whitefish (Falkowski 1992; Szczerbowski 1993). As hydrochemical conditions deteriorated in the 80s the Miedwie whitefish was thought to be extinct in Lake Miedwie (Trzebiatowski et al. 1988; Heese 1990). However, in the 90s the water purity in this lake improved and the autochtonic population of the whitefish was restored (Pietrucha 1999).

Our studies on the susceptibility of the eggs of respective fish species inhabiting Polish waters (Czeczuga and Muszyńska 1999a, b), including the coregonid species (Czeczuga and Muszyńska 1998) to zoosporic fungi have found it to be environment-dependent. Certain stressogenic factors, such as low oxygen content, high temperature or even food insufficiency affect the condition of coregonid females, whose eggs are more susceptible to various infections. Moreover, a different number of fungi also developed on the eggs of three subspecies of *Coregonus lavaretus*.

Taking the above factors into consideration we decided to examine the eggs of Miedwie whitefish with respect to their susceptibility to infections due to aquatic zoosporic fungus species, and to investigate this subspecies inhabiting Lake Miedwie for centuries in relation to other already examined subspecies of *Coregonus lavaretus* (cf. Czeczuga and Muszyńska 1998).

MATERIAL AND METHODS

A female of *Coregonus lavaretus maraena* (Bloch, 1779) was caught in Lake Miedwie on 22 December 1999 at a depth of 15 m. Its total length was 47.5 cm, caudal length 44.0 cm and weight 1 040 g, with 34 gill rakers on the first branchial arc.

The following types of water bodies of northeaster Poland were investigated:

- Spring Cypisek – limnokrenic type, width 0.41 m, depth 0.17 m, discharge 0.6 dm^3/s; the northern part of Białystok; single pine trees.
- Spring Jaroszówka – limnokrenic type, width 0.65 m, depth 0.12 m, discharge 2.4 dm^3/s; the northern part of Białystok; witheast trees.
- River Supraśl – length 106.6 km, is the right-bank tributary of the middle part of the Narew River, flowing through the Knyszyńska Forest. The samples were collected from the site above the municipal swimming pool at the sluice of an arm of the Supraśl River flowing just through the town of Supraśl.
- Pond Akcent – area 0.45 ha, max. depth 1.50 m, contains wild ducks and breeding swans.

  Pond Fosa – area 2.5 ha, max. depth 1.75 m, is in the Palace Park – and contains wild ducks and breeding swans as well as crucian carp and tench bred for anglers.
- Lake Komosa, area 12.1 ha, max. depth 2.25 m, surrounded densely by coniferous trees of the Knyszyńska Forest.

Nineteen water parameters of the above sampling sites were determined (Table 1) following the methods of Greenberg et al. (1992).

Table 1

Chemical composition (in $mg \cdot dm^{-3}$) of water from different sampling sites (n = 3)

Specification	Cypisek Spring	Jaroszówka Spring	Supraśl River	Akcent Pond	Fosa Pond	Komosa Lake
Temperature °C	6.0	3.8	4.5	2.3	1.4	2.8
pH	7.69	7.91	7.84	7.33	7.22	7.88
O_2	10.4	11.8	13.2	1.0	5.8	12.2
BOD_5	3.8	3.8	12.0	1.0	4.6	5.0
COD	2.50	5.40	10.94	26.50	14.44	8.45
CO_2	13.2	15.4	8.8	41.8	17.6	8.8
Alkalinity in $CaCO_3$ (in $mval \cdot dm^{-3}$)	5.2	5.9	4.4	8.2	6.1	4.3
N (NH_3)	0.040	0.805	0.195	4.180	0.700	0.245
N (NO_2)	0.027	0.194	0.013	0.032	0.006	0.008
N (NO_3)	3.000	5.010	0.750	0.190	0.050	0.360
P (PO_4)	0.800	3.565	0.750	7.080	1.245	0.735
Sulphates	50.60	54.71	19.75	91.74	47.31	32.91
Chlorides	24.0	23.0	16.0	46.0	44.0	14.0
Total hardness in Ca	117.36	123.84	79.20	150.48	101.52	79.20
Total hardness in Mg	16.77	15.48	14.19	31.82	29.67	9.89
Fe	0.60	0.75	0.85	1.05	0.50	0.85
Dry residue	456	443	262	669	529	230
Dissolved solids	420	426	247	636	517	218
Suspended solids	36	17	15	33	12	12

For the determination of the presence of aquatic fungal species on the eggs, the following procedure was employed: a certain number of eggs (100–200) of Miedwie whitefish was transferred to two samples of water representing each site, in an 1.0 dm^3 vessel (all together twelve vessels) and placed in the laboratory at ambient temperature. A part of eggs from each vessel was observed under a microscope and the mycelium (zoosporic, antheridia, oogonia and for *Saprolegnia parasitica*—secondary cysts) of aquatic fungi growing on the eggs was recorded. The methods are described in detail by Smith et al. (1985) and Fuller and Jaworski (1986). The eggs on the Miedwie whitefish were observed under a microscope for one a half weeks. The majority of eggs was alive but some were dead. The duration of the experiments was three weeks. Identification of the fungi was aided the following keys: Johnson (1956), Sparrow (1960), Seymour (1970), Batko (1975), Karking (1977) and Dick (1990).

RESULTS

Under laboratory conditions 32 aquatic zoosporic fungus species developed on the eggs of Miedwie whitefish, including 24 of the order Saprolegniales and 8 of the Peronosporales (Table 2). The largest number of fungus species developed in the water of Komosa Lake (14), the smallest in pond Akcent (5). *Saprolegnia parasitica* was found on the eggs in the water of five reservoirs (except pond Akcent), two species of *Saprolegnia ferax* in four water basins (except the Supraśl River and pond Fosa), and *Saprolegnia monoica* (except Supraśl River and pond Akcent). Two species of the order Peronosporales appeared new to Polish waters: *Pythium acanthicum* found to grow on the whitefish eggs in the water of pond Akcent and *Pythium catacearum* in spring Cypisek. Of the 32 zoosporic aquatic fungus species found, 15 are known as parasites or necrotrophs of different fish species.

DISCUSSION

Compared with other subspecies of *Coregonus lavaretus* inhabiting Polish waters such as *C. lavaretus generosus* and *C. lavaretus lavaretus*, and *C. lavaretus wartmanni* from Finland waters (Lake Konnevesi), whose eggs was examined for susceptibility to aquatic fungus infections (Czeczuga and Muszyńska 1998), the eggs of *C. lavaretus maraena* has appeared vulnerable to the infection. Only 9 fungus species known as fish parasites were noted on the eggs of *C. lavaretus generosus*, 13 on *C. lavaretus lavaretus* and 13, while 15 on the *C. lavaretus maraena* subspecies. The eggs of *C. lavaretus wartmanni* was infected in the same conditions by 6 parasitic fungus species. The eggs of *C. lavaretus generosus* and *C. lavaretus wartmanni* subspecies was obtained from females living in natural environment, while the eggs of *C. lavaretus lavaretus* subspecies from a fish-farm (Rutki near Gdynia), where like in any the artificial breeding various stressogenic factors occur (Saksena 1999). We can explain low resistance of the *C. lavaretus lavaretus* eggs to mycotic infections by stressogenic factors. A reduction in water oxygen below 6 $mg \cdot dm^{-3}$ is stressogenic for the salmonids (Wedemeyer 1997). If the amount of oxygen in the lower part of hypolimnion decreases, the whitefish moves to the upper layers with higher oxygen content, but there water temperature is elevated, which is also stressogenic for this fish, being a cold-water species.

At the beginning of the 90s a total loss of oxygen was observed in the hypolimnion of Lake Miedwie (Mutko and Wierzchowska 1996) and sulphur hydrogen was present at the bottom. Even the improvement of water purity observed at the end of the 90s did not allow complete elimination of the stressogenic factor. Whitefish females, in the summer period of gonad development, in diverse stressogenic conditions lay the eggs, more or less susceptible to mycotic infections. This could explain poor condition of the *C. lavaretus maraena*

population and females of this subspecies in Lake Miedwie. Moreover, in the whitefish species the eggs are deposited at the spawning ground for a few months between the spawning-time and larval development and unless it is immune to mycotic infections it may be destroyed by aquatic zoosporic fungi. It should be remembered that the growth of the Saprolegniales is more intensive at water temperature of a few degrees above zero. This is a likely mechanism of the effect of lake eutrophization on the extinction of whitefish populations. According to our recent studies, bottom crustaceans and shellfish, both included in the food of whitefish (Gąsowska 1965; Trzebiatowski et al. 1988), are vectors of parasitic zoosporic fungi for fish. Such three dangerous species as *Saprolegnia delica*, *Saprolegnia ferax* and *Saprolegnia parasitica*, causing great fish losses, can be found on *Asellus aquaticus*, *Pallasiola quadrispinosa* and on the three species of the genus *Gammarus* examined (Czeczuga et al. 1999). This also refers to the majority of the zooplankton species examined (Czeczuga et al. 2000).

There fungus species of the genus *Pythium* found on the eggs of Miedwie whitefish – *Pythium acanthicum*, *Pythium butleri* and *Pythium cactacearum* have near been encountered on fish (Czeczuga 1996) nor in Polish waters. They were first described in plants (Dick 1990). *Pythium acanthicum* was isolated by Drechsler (1930) from fallen fruits of *Citrullus vulgaris* L. in Florida and in some other States. *Pythium butleri* was first described as a parasite of several plants, including *Nicotiana tabacum, Capsicum annuum* and *Solanum tuberosum* (Subramaniam 1919). *Pythium cactacearum* was also described as a parasite of *Phyllocactus phyllanthoides* in Italy near San Remo by Preti (1936). In our study, *Pythium acanthicum* was observed to grow on the whitefish eggs in the water of pond Akcent, *Pythium butleri* in spring Jaroszówka and the River Supraśl, while *Pythium cactacearum* in the water of spring Cypisek.

The present study has revealed that the water reservoir exerts an effect both on the total number of fungus growing on the eggs of Miedwie whitefish and on the number of parasitic or necrotrophic fungi. The largest numbers of fungi in general and those parasitic or necrotrophic were found in the water of Lake Komosa, pond Fosa and spring Cypisek, the smallest in pond Akcent, spring Jaroszówka and the River Supraśl. We have established that this is also substrate-dependent.

The eggs of one fish species is colonised by more fungus species in the oligotrophic-like water (springs), the eggs of others in eutrophic type waters (ponds) (Czeczuga and Muszyńska 1998, 1999a, b).

Table 2

Aquatic fungi found on the eggs of *Coregonus lavaretus maraena*

Fungi	Water bodies					
	Cypisek Spring	Jaroszówka Spring	Supraśl River	Akcent Pond	Fosa Pond	Komosa Lake
Saprolegniales						
1. *Achlya americana* Hymphrey *				×		×
2. *Achlya apiculata* de Bary					×	×
3. *Achlya crenulata* Zeigler	×					
4. *Achlya debaryana* Humphrey	×				×	×
5. *Achlya klebsiana* Pieters *						×
6. *Achlya megasperma* Humphrey			×			
7. *Achlya oblongata* de Bary			×		×	×
8. *Achlya polyandra* Hildebrand *			×			
9. *Achlya prolifera* Nees *	×		×			
10. *Achlya treleaseana* (Humphrey) Kauffman					×	
11. *Aphanomyces laevis* de Bary *						×
12. *Dictyuchus sterile* Coker *					×	
13. *Saprolegnia delica* Coker *	×				×	
14. *Saprolegnia diclina* Humphrey *					×	
15. *Saprolegnia ferax* (Gruith.) Turnet *	×	×		×		×
16. *Saprolegnia furcata* Maurizio				×		
17. *Saprolegnia glomerata* (Tiesenhausen) Lund	×			×		
18. *Saprolegnia irregularis* Jonson et Seymour						×
19. *Saprolegnia latvica* Apinis	×	×				
20. *Saprolegnia mixta* de Bary *					×	
21. *Saprolegnia monoica* Pringsheim *	×	×			×	×
22. *Saprolegnia parasitica* Coker *	×	×	×		×	×
23. *Saprolegnia shikotsuensis* Hatai et al. *			×			×
24. *Thraustotheca clavata* (de Bary) Humphrey*	×				×	
Peronosporales						
25. *Pythium acanthicum* Drechsler				×		
26. *Pythium artotrogus* de Bary *						×
27. *Pythium butleri* Subramaniam		×	×			
28. *Pythium cactacearum* Preti	×					
29. *Pythium debaryanum* Hesse		×				
30. *Pythium middletonii* Sparrow						×
31. *Pythium polysporum* Sorokin					×	×
32. *Pythium proliferum* Schenk		×				
Total number **	11(6)	7(3)	7(4)	5(2)	12(7)	14(8)

* Known in literature as parasites or necrotrophs of fish

** Numbers in parenthesis in the last row designate the total number of parasites or necrotrophs

CONCLUSIONS

A total of 32 aquatic fungus species was found under laboratory conditions in spring water, pond, lake and the river on the eggs of *Coregonus lavaretus maraena* from Lake Miedwie in Pomerania.

The largest number of aquatic fungi occurred on eggs in the water poor in biogenes (Lake Komosa), the smallest number in the water abundant in these compounds (pond Akcent).

Among the fungus species found, two are new to fish and to Polish hydromycology.

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GRZYBY ROZWIJAJĄCE SIĘ NA IKRZE *COREGONUS LAVARETUS MARAENA* (BLOCH, 1779) Z JEZIORA MIEDWIE NA POMORZU

STRESZCZENIE

Badano w warunkach laboratoryjnych występowanie pływkowych grzybów wodnych na ikrze siei miedwieńskiej (*Coregonus lavaretus maraena*) z jeziora Miedwie. Do doświadczeń używano wody z 6 różnych limnologicznie zbiorników, uwzględniając w niej poszczególne parametry hydrochemiczne.

Ogólnie stwierdzono na ikrze siei miedwieńskiej rozwój 32 gatunków pływkowych grzybów wodnych, w tym dwa gatunki nowe dla hydromikologii Polski (*Pythium acanthicum* i *Pythium catacearum*).Wśród stwierdzonych gatunków 24 należały do rzędu Saprolegniales, zaś 8 do Peronosporales. Najmniej gatunków rozwijało się w najbardziej eutroficznej wodzie stawu Akcent (5), najwięcej – w wodzie jeziora Komosa (14).

Received: 29 June 2000

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